Transforming Drug Therapy with Deep Learning: The Future of Personalized Medicine

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Abstract

Abstract Personalized medicine represents a paradigm shift in healthcare, aiming to tailor treatment strategies to the unique genetic, environmental, and lifestyle characteristics of individual patients. This approach holds immense potential for improving therapeutic efficacy and minimizing adverse drug reactions. With the rapid advancement of artificial intelligence, deep learning has emerged as a transformative tool in pharmacology, enabling precise modeling of complex biological data and uncovering hidden patterns in patient-specific information. This study investigates the application of deep learning techniques – such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Transformer architectures, and Generative Adversarial Networks (GANs) – in optimizing personalized treatment strategies. Using a diverse dataset comprising electronic health records (EHRs), genomic sequences, and clinical indicators, we developed and trained deep learning models for tasks including drug response prediction, biomarker identification, and adverse drug reaction (ADR) forecasting. Among the models evaluated, Transformer-based architectures demonstrated superior performance, achieving an accuracy of 91.2% and an AUC-ROC of 0.92 in drug response prediction tasks. Moreover, the integration of deep learning models into the treatment pipeline resulted in a 20–30% improvement in drug-patient matching efficiency compared to traditional statistical methods. The findings underscore the potential of AI-powered systems to enhance clinical decision-making and enable precision pharmacotherapy. However, challenges such as data privacy, model interpretability, and regulatory compliance remain critical barriers to widespread adoption. The study also explores future directions, including the implementation of explainable AI (XAI) and federated learning, to address these limitations and facilitate the integration of deep learning into routine clinical practice.